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Optimized Structural Analysis and Design of a Long-Span Pre-Engineered Steel Warehouse using STAAD.Pro

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Abstract

Structural design is aimed to design a structure that full fills its intended purpose during its intended life span and be adequately safe in terms of strength, stability, and structural integrity, serviceability in terms of stiffness, durability, etc., and be economically viable, aesthetically pleasing, and environment friendly. This paper presents the studies on the analysis and design of the steel warehouse structure. The optimum design of the structure is carried out using finite element software STAAD Pro. The analysis of the structure is carried out for suitable steel sections with different load carrying capacity. The steel quantity required for the structure is calculated. Finally, along with material optimization, techno-economical design to achieve the reliable performance of the warehouse structure is carried out.

***Keywords: Pre* –** Engineered Buildings (Ware House), STAAD Pro, Finite element method**.**

I.INTRODUCTION

In recent years, rapid industrial growth and increasing demand for large storage facilities have led to the widespread adoption of **Pre-Engineered Steel Buildings (PEB)** for warehouse construction. Long-span steel warehouses are preferred due to their structural efficiency, speed of construction, lightweight characteristics, and economic advantages. Unlike conventional steel structures, pre-engineered buildings are designed using optimized tapered sections that reduce material usage while maintaining strength and stability. The integration of computer-aided structural analysis tools such as **STAAD.Pro** enables engineers to evaluate multiple design alternatives and achieve an optimized, safe, and economical structural system.

A long-span steel warehouse is typically designed to provide large column-free spaces for efficient storage and movement of goods. Such structures are subjected to various loading conditions including **dead load (DL), live load (LL), wind load (WL), and load combinations** as per relevant Indian Standard codes such as IS 875 and IS 800:2007. Due to the large span and height of industrial warehouses, wind load plays a significant role in structural design. Proper bracing systems, purlins, and rigid frame action are essential to resist lateral forces and ensure overall structural stability. Therefore, accurate modeling and finite element analysis become crucial to predict deflections, shear forces, bending moments, and stresses in the structural members.

The objective of this study is to perform optimized structural analysis and design of a long-span pre-engineered steel warehouse using STAAD.Pro. The research focuses on evaluating different steel sections, analyzing various load combinations, checking serviceability criteria such as deflection limits, and reducing overall steel weight for economic efficiency. Additionally, foundation design is carried out using STAAD Foundation based on support reactions obtained from the analysis. The study aims to demonstrate that pre-engineered steel warehouses provide a cost-effective, sustainable, and structurally efficient solution for modern industrial infrastructure, especially for large clear-span applications.

II.LITERATURE REVIEW

The design and optimization of long-span pre-engineered steel warehouse structures have been widely studied in recent years due to increasing industrial demand and the need for economical structural solutions. Researchers have focused on comparative analysis between conventional steel buildings (CSB) and pre-engineered buildings (PEB), optimization of steel sections, finite element modeling, and the influence of load combinations on structural performance.

G. Durga Rama Naidu (2014) conducted a comparative study between pre-engineered buildings and conventional steel frames using structural analysis software. The study concluded that PEB structures significantly reduce steel consumption due to the use of tapered built-up sections, resulting in cost savings and improved structural efficiency. It was observed that optimized PEB frames can reduce overall steel weight by nearly 20–30% compared to conventional hot-rolled sections.

S.D. Charkha (2014) focused on economizing steel structures using pre-engineered steel sections. The research emphasized that tapered sections are more efficient because they match the bending moment diagram, providing more material where stresses are higher and reducing material in low-stress regions. This approach improves material utilization and reduces structural weight without compromising safety.

C.M. Meera (2013) performed a detailed analysis and design of an industrial warehouse using STAAD.Pro. The study compared conventional and pre-engineered building frames under various load combinations. Results showed that PEB structures perform better for long-span industrial applications due to reduced deflection and improved structural behavior under wind loading conditions.

Milind Bhojkar (2014) analyzed the cost and time effectiveness of PEB systems. The research highlighted that pre-engineered steel warehouses reduce construction time due to prefabrication and simplified erection processes. The study concluded that PEB systems are more economical and environmentally friendly compared to conventional steel buildings, especially for larger spans.

Vaibhav B. Chavan (2014) investigated optimum span length for industrial structures and found that material optimization depends on bay spacing and frame geometry. Increasing bay spacing up to an optimum value reduces steel quantity; however, beyond that limit, member sizes increase, leading to higher weight.

Manan D. Maisuri (2013) compared conventional steel sections with tubular steel sections in industrial trusses. The research demonstrated that hollow tubular sections provide better strength-to-weight ratio and improved structural performance due to higher torsional rigidity. Tubular sections were found to be more economical in certain industrial applications.

A. Jayaraman et al. studied the behavior and economy of roof trusses and purlins using Limit State Method (LSM) and Working Stress Method (WSM). The study concluded that LSM provides a more rational and economical design approach compared to WSM for industrial steel structures.

Yash Patel (2006) emphasized the advantages of tubular steel sections in industrial roof trusses. The study concluded that tubular sections provide better aesthetic appearance, lower maintenance cost, and improved load distribution.

Recent research trends also focus on the integration of advanced analysis tools such as finite element method (FEM) for accurate prediction of structural behavior. Software like STAAD.Pro enables 3D modeling, load combination analysis, deflection checks, stress evaluation, and optimization of steel members under various loading conditions as per IS 800:2007 and IS 875 provisions.

III.WORKING METHODOLOGY

The working methodology for the optimized structural analysis and design of a long-span pre-engineered steel warehouse using STAAD.Pro involves systematic modeling, loading, analysis, design, and optimization procedures in accordance with relevant Indian Standard codes. Initially, the geometric modeling of the warehouse structure is carried out in STAAD.Pro. A three-dimensional (3D) space frame model is developed representing the industrial warehouse with appropriate span length, bay spacing, roof slope, and height. Structural components such as columns, rafters (tapered sections), purlins, bracings, and tie members are modeled accurately. Node generation, beam connectivity, and translation repeat commands are used to create repetitive frames efficiently. Groups are created for columns, beams, and bracings to simplify property assignment and load application. Steel material properties are assigned as per IS 800:2007 specifications.

After modeling, sectional properties are defined using appropriate steel sections such as tapered I-sections, channels, pipes, and rolled sections selected from the section database. Support conditions are assigned at base nodes, typically as fixed supports to simulate rigid foundation behavior. The next step involves defining loads acting on the structure. Dead load (DL) includes self-weight of structural members and roofing components. Live load (LL) is applied as per IS 875 (Part 2), considering roof slope reduction factors. Wind load (WL) is calculated and applied as per IS 875 (Part 3), including internal and external pressure coefficients

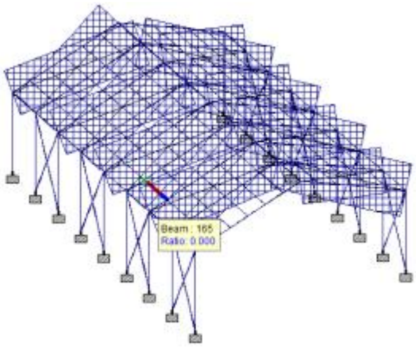

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Fig 1 :Moment in X-direction

Moment in X-direction in fig 1(often shown as torsion in STAAD.Pro) represents twisting of the beam about its longitudinal axis. Torsional moments are developed due to eccentric loading, unsymmetrical sections, or wind load acting on one side of the roof. In pre-engineered buildings, torsion is generally smaller compared to bending moments but cannot be neglected, especially in edge frames and braced bays. The torsion diagram shows localized peaks at connections and bracing locations. Proper connection detailing and stiffeners are required to resist torsional stresses. Torsional resistance is checked using IS 800:2007 provisions to ensure structural safety.

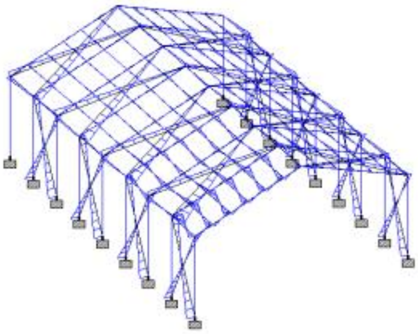

Fig 2:Moment in Y-direction

The Moment in Y-direction Fig 2 represents bending about the local Y-axis of the beam. This moment is generally caused by lateral loads such as wind pressure acting perpendicular to the frame plane. Compared to Mz, My is usually smaller in magnitude but becomes significant in purlins and secondary members. The diagram shows variation of moment along the frame length and indicates the effect of wind load combinations. In long-span warehouses, lateral stability systems such as bracings are designed considering My values. This moment is critical for checking weak-axis bending capacity of steel members as per IS 800:2007.

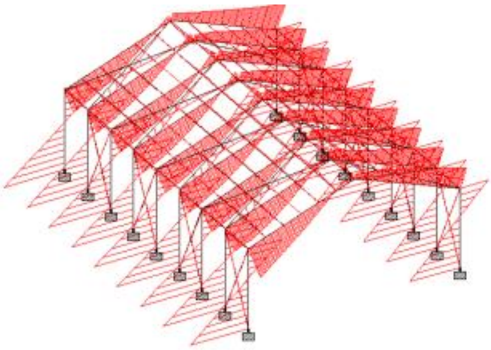

Fig 3:Moment in Z-direction

The Moment in Z-direction Fig 3 represents bending about the local Z-axis of the beam member. In portal frame type warehouse structures, Mz is usually the major bending moment because gravity loads (roof loads) cause bending in the vertical plane of the frame. The diagram shows maximum positive bending at mid-span of rafters and negative bending at supports (column-rafter junctions). The magnitude of Mz is generally higher in central frames due to larger tributary area. This bending moment governs the design of the primary framing members, especially tapered rafters and columns. Proper flange thickness and web depth are selected to resist this moment efficiently. The diagram confirms that bending behavior follows the expected portal frame action.

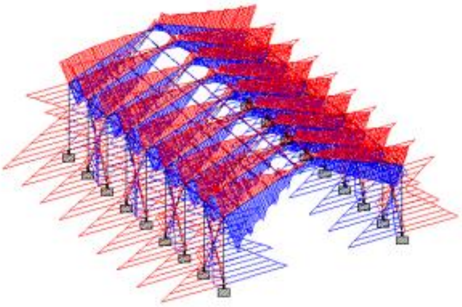

Fig 4: Beam Stress diagram

The Beam Stress diagram fig 4 represents the stress distribution developed in the beam members due to applied loads such as Dead Load (DL), Live Load (LL), and Wind Load (WL). The red and blue stress contours indicate zones of higher and lower stresses respectively. Maximum stresses are generally observed near beam-column connections and at regions where bending moments are high, such as mid-span of rafters. In long-span pre-engineered warehouses, stresses are more significant in tapered rafters because they resist both gravity and lateral loads. The stress diagram helps in verifying whether the induced stresses are within permissible limits as per IS 800:2007. If the stress exceeds allowable values, section modification or optimization is required. The diagram confirms that stress distribution follows the bending moment pattern and is higher in regions subjected to maximum flexural action.

IV. CONCLUSIONS

The following are the major observation and conclusion drawn from the present project work.

* The Pre Engineered Buildings (steel warehouse) is analysed for the respected loads acting on the structure as per the codes.

* The warehouse structure is analysed for the different load combinations.

* The materials quantity is calculated for the optimized design of the structure.

* Time saving design with respect to computer aided design of structure (CADS).

It can be said that pre-engineered buildings are more economical and also environmental friendly than conventional steel structures since the steel used in pre-engineered buildings can be recycled in case of demolition and hence it becomes a more sustainable approach. As it is seen in the present work, the weight of steel can be reduced to 30% for warehouse using Tapered I sections. For longer span structures, Conventional buildings are not suitable with clear spans. Pre-engineered building are the best solution for longer span structures without any interior column in between as seen in this present work, an industrial structure has been designed for 88m. With the advent of computerization, the design possibilities became almost limitless. More materials can be saved on low stress area of primary framing members and thus making it convenient for low rise building spanning upto 90 metres. PEB structures are found to be costly as compared to Conventional structures in case of smaller span structures. It is also seen that the weight of PEB depends on the Bay Spacing, with the increase in Bay Spacing up to certain spacing, the weight reduces and further increase makes the weight heavier. To conclude, pre engineered structures are more suitable for longer spans building as consumers prefers more space in a structure.

REFERENCES

1.1.G.Durga Rama Naidu, Comparative study of analysis and design of pre-engineered buildings and conventional frames- IOSR Journal of mechanical and civil engineering ISSN: 2278-067X, 2014, 10, , pp 165-169.
2. S.D.Charkha, Economizing steel building using pre-engineered steel sections – International journal of scientific and engineering research, 2014, 6 (12), pp 69-74.
3..Milind Bhojkar, Comparison of pre-engineered building and steel building with cost and time effectiveness – International journal of innovative science engineering and technology ISSN 2348-7968, 2014, 1 (10), pp 784-789
4.VrushaliBahadur , Comparison between design and analysis of various configuration of industrial sheds – International journal of engineering research and applications, 2013, 3(1), pp-1565-1568.
5.M.Suneetha1,Naresh Kumar, Gillela Reddy October 2016, “Design and Analysis of Industrial Building with Gable Roof by using STAAD.PRO” International Journal of Advance Technology In Engineering and Science.
6 . Vaibhav B. Chavan, Vikas N. Nimbalkar And Abhishek P. Jaiswal, Vol. 3, Issue 2, February 2014 “ Economic Evaluation Of Open And Hollow Stuctural Sections In Industrial Trusses”, Aci Structural Journal.
7.C.M. Meera, June 2013 “Pre- Engineered Building Design of an Industrial warehouse”. International Journal of Engineering Sciences and Emerging Technologies.
8.SubhrakantMohakul, Dr. Shaikh Yajdani, Abhay Dhurde,August 2014 “Design of industrial storage shed and analysis of stresses produced on failure of a joint”. International Journal of Civil Engineering and Technology.
9.Manan D.Maisuri, Hitesh K.Dhameliya, Hiten L.Kheni, Vol.1 Issue 12, December 2013, “Review Of Comparison Between Conventional Steel And Tubular Steel Section For Multi Span Industrial Shed With Truss And Portal Frame” International Journal of Advance Engineering and Research Development.
10.ShaivParikh ,”Design of Steel Compression Members” (According To IS: 800)
11.Yash Patel, Shreepalsinh Gohil, Dr .TausifKauswala ,Het Parmar, volume 3 issue 10, april2006, “Analysis And Design Of Conventional Industrial Roof Truss And Compare It With Tubular Industrial Roof Truss” International Journal of Science Technology and Engineering.
12.A.Jayaraman, R Geethamani, N Sathyakumar,NKarthigaShenbagam,“Design and Economical of Roof Trusses & Purlins (comparison of LSM and WSM)” Design of S